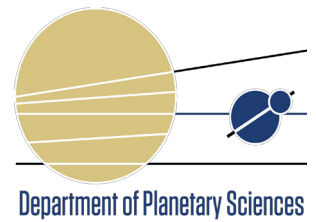




UA SCIENCE

# LUNAR & PLANETARY LABORATORY

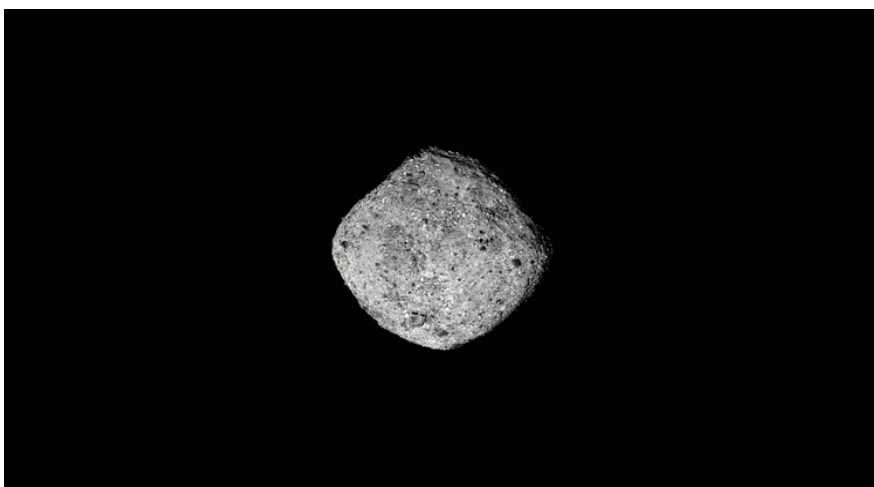


LUNAR AND PLANETARY LABORATORY NEWSLETTER

FALL 2018

## UA-Led OSIRIS-REx Discovers Water on Asteroid Bennu

by Erin Morton/OSIRIS-REx and Daniel Stolte, University Communications | December 10, 2018



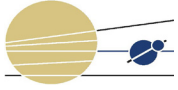
OSIRIS-REx arrived at asteroid Bennu on December 3, and in a key finding, data obtained from the spacecraft's two spectrometers reveal the presence of molecules that contain oxygen and hydrogen atoms bonded together. The team suspects that these hydroxyl groups exist globally across the asteroid in water-bearing clay minerals, meaning that at some point, the rocky material interacted with water. While Bennu itself is too small to have ever hosted liquid water, the finding does indicate that liquid water was present at some time on Bennu's parent body, a much larger asteroid.

“This finding may provide an important link between what we think happened in space with asteroids like Bennu and what we see in the meteorites that scientists study in the lab,” said [Ellen Howell](#), LPL senior research scientist and member of the mission's spectral analysis group. “It is very exciting to see these hydrated minerals distributed across Bennu's surface, because it suggests they are an intrinsic part of Bennu's composition, not just sprinkled on its surface by an impactor.”

Data obtained from the OSIRIS-REx Camera Suite (OCAMS) corroborate ground-based radar observations of Bennu and confirm that the original model—developed in 2013 by OSIRIS-REx Science Team Chief [Michael Nolan](#) (LPL) and collaborators using Arecibo Observatory radar data—closely predicted the asteroid's actual shape. The mission team used this model when designing the OSIRIS-REx mission. Its accuracy means that the mission, spacecraft, and planned observations were appropriately designed. One outlier from the predicted shape model is the size of the large boulder near Bennu's south pole. The ground-based shape model calculated this boulder to be at least 33 ft (10 m) in height. Preliminary calculations from OCAMS observations show that the boulder is closer to 164 feet (50 meters) in height, with a width of approximately 180 ft (55 m).

As expected, the initial assessment of Bennu's regolith indicates that the surface of Bennu is a mix of very rocky, boulder-filled regions and a few relatively smooth regions that lack boulders. However, the quantity of boulders on the surface is higher than was expected. The team will make further observations at closer ranges to more accurately assess where a sample can be taken on Bennu for later return to Earth.

“Our initial data show that the team picked the right asteroid as the target of the OSIRIS-REx mission. We have not discovered any insurmountable issues at Bennu so far,” said [Dante Lauretta](#), OSIRIS-REx principal investigator and professor of planetary science at LPL. “The spacecraft is healthy and the science instruments are working better than required. It is time now for our adventure to begin.”



## Welcome from the Director



Are we there yet?

At last, we can stop asking that, when it comes to **OSIRIS-REx**. After nearly a decade of planning and proposing, several years of building instruments, and more than two years of flight, the spacecraft finally arrived at its target asteroid, Benu, on December 3. In some ways, though, the work is just beginning, with the team mapping and characterizing the asteroid as quickly and as thoroughly as possible in preparation for collecting a sample.

In a way, we can also stop asking the question about **Parker Solar Probe**. After even more years of planning, but only a few months in flight, it made its first perihelion passage in November. But it's not quite there yet, because over the next six years, it will get closer to the Sun each time it goes by.

But OSIRIS-REx and Parker Solar Probe aren't the only things happening at LPL. We've got graduate students, faculty and staff coming and going, and, as always, lots of fascinating science being done. So enjoy our semi-annual newsletter, which focuses more on the events within LPL, and we hope you enjoy getting our monthly electronic version, which features a couple of recent news items about LPL each month.

**Timothy D. Swindle, Ph.D.**

Department Head and Laboratory Director

## Department

### Zachary Adam, LPL Staff Scientist

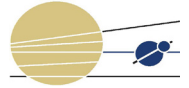
**Zach Adam** recently joined LPL as an Associate Staff Scientist with a focus on the origins of life, the origins of eukaryotes, and the possible distribution of complex life in our universe. He came to LPL after a postdoc fellowship through the Simons Collaboration on the Origins of Life, where he and his colleagues conducted gamma ray irradiation experiments on aqueous mixtures of simple carbon compounds. Together they discovered new, efficient pathways for the production each of the precursors predicted for RNA World scenarios. Before this assignment, he was a graduate student at Montana State University, where he discovered two new sources of microfossils in the rocks of the Belt Supergroup. These microfossils included beautifully preserved specimens of some of the oldest eukaryotes known from the fossil record. And before this he was a launch vehicle inspector for the federal government, where he got the chance to serve on the licensing teams for the SpaceX Falcon 1, Falcon 9 and Dragon and Sea Launch Zenit-3SL programs.



Outside of work, Zach loves playing games with his wife and baby son, running in all kinds of weather, and fixing broken machines. He is moved by a strong (and perhaps naive) belief that the cultivation of knowledge follows universal patterns.

### Bystander Workshop at LPL

PTYS alumnus **Dr. Moses Milazzo** facilitated a **Bystander Intervention Workshop** at LPL on October 29. Among the thirty-two participants were faculty, staff, and graduate students from LPL and Steward Observatory. Dr. Milazzo created the U.S.G.S. StepUp! Employee Empowerment Strategies, based on the **University of Arizona's StepUp! Bystander Intervention Program**, and adapted it to the professional science environment (e.g., conference experiences).



## Faculty

### Welcome, Kris Klein



This fall, [Dr. Kristopher Klein](#) joined the LPL faculty as an Assistant Professor. Professor Klein earned a Ph.D. in Physics in 2013 from the University of Iowa, where he studied turbulence in weakly collisional plasmas (ionized gases) such as the solar wind. From 2014 to 2016, he worked at the University of New Hampshire as a National Science Foundation Atmospheric and Geospace Science Postdoctoral Research Fellow, constructing observational signatures for different turbulent heating mechanisms. In 2016, he moved to the University of Michigan to work on the science team preparing predictions for NASA's Parker Solar Probe mission. This mission, which launched in August, will travel to within 4 million miles of the Sun's surface and reveal for the first time the mechanisms that lead to the solar wind's heating and acceleration.

At LPL, Professor Klein continues to work on characterizing the transfer of energy from turbulent electromagnetic fields to plasma heat and the effects of such transfer on the solar wind and other collisionless plasmas, through analytic methods and large scale numerical simulations. He also is working on planning for the next generation of spacecraft that will help bring closure to these and other questions about our Sun and its extended atmosphere.

### Kudos for Hamilton

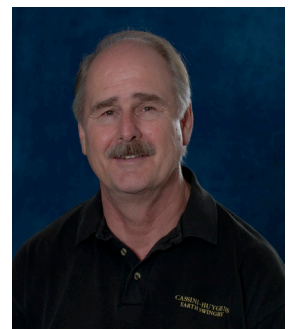
Kudos to [Assistant Professor Christopher Hamilton](#), named one of *Science News* magazine's 10 young scientists to watch (SN10; the only planetary scientist in the list). Christopher spends some of his time studying terrestrial volcanic areas like Iceland and Hawai'i, and then applies that knowledge to volcanoes all over the solar system.

Professor Hamilton received the Geological Society of America (GSA) Early Career Award in the Mineralogy, Geochemistry, Petrology, & Volcanology Division and was previously awarded a NASA Early Career Fellowship and a faculty fellowship from NASA Marshall Space Flight Center, which provided a stipend and a 10-week summer residency at Marshall Space Flight Center.

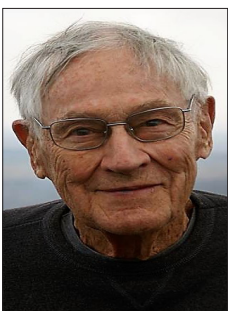


### Robert Brown to Emeritus

This September (2018), [Professor Robert Brown](#) transitioned to Emeritus status. Professor Brown, who holds a joint appointment in Planetary Sciences and Astronomy, began his career at LPL in 1996. He served as Team Leader for the Visible Infrared Mapping Spectrometer (VIMS) facility instrument on the Cassini Orbiter (1990-present) and will be actively engaged in finalizing Cassini mission research until September 2019.

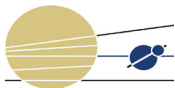


### Bradford Smith, 1931-2018



[Brad Smith](#), retired University of Arizona professor of Planetary Sciences and Astronomy, passed away on July 3, in Santa Fe, New Mexico. More information about Brad's life and career is available from <http://shorelips.net/bradsmith/>

LPL was privileged to host a memorial service for Professor Smith on September 22.



## Department

### UA Arizona/NASA Space Grant

Susan Brew, who served as Program Manager for UA and Arizona NASA Space Grant Consortium since its beginning in 1988, transitioned to retirement this fall. During her career with Space Grant, Susan directly supported over 1,300 UA students—future STEM leaders, mentors, and affiliates; her work has positively impacted the lives of countless others across the nation. Susan spent much of the past few months working with her successor, [Michelle Coe](#).



Michelle officially joined LPL in July 2018 as the Program Manager for the Arizona/NASA Space Grant Consortium. Michelle, who is a past Space Grant undergraduate intern and Space Grant Fellow at the University of Arizona, is excited to come full-circle and get the opportunity to work alongside affiliates, students, and mentors across the state. Before joining LPL, Michelle worked for several years leading an (originally Space Grant-funded) environmental science program that was an extension of the UA Geography Department's Community and School Garden Program. During that time, she worked with K-12 students on citizen science activities related to current environmental science projects happening at the university. Most recently, she worked with students collecting data for the Biosphere 2's Agrivoltaics (agriculture + photovoltaics) research project.

Michelle is originally from a small town called Boulder City, Nevada, that was built up around the Hoover Dam. She loves to spend time with friends, family, and her Shiba Inu, Morde. You may find her outside spying on insects and plants, bicycling around town, or at home watching *The Great British Baking Show* while trying out a new recipe!

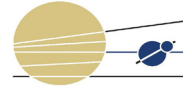
### Nocturnal Aviation at Hawthorne House

*Thanks to LPL alum Cliff Stoll for forwarding this piece of graduate student history.*

Ever hear of Nocturnal Aviation? From 1976 to 1981, LPL grad students [Guy Consolmango](#), [Nick Gautier](#), [John Wacker](#), and [Cliff Stoll](#) ran a T-shirt printing enterprise. Nick built a wooden T-shirt printing press; John drove up to Phoenix and bought a few hundred blank shirts; Guy found space for the backyard escapade; Cliff arm-twisted the Kitt Peak Visitor Center into purchasing them. Together, we designed astronomical T-shirts and printed them using hand-cut silk screens.

Every few months, we'd gather at Hawthorne House, home to LPL grad students, and squeeze ink through silk screens onto shirts. The stellar and solar designs sold like hotcakes up at Kitt Peak—supplementing our meager graduate assistantships with ink-spattered lucre. Other grad students tagged along for the nuttiness. Occasionally, a faculty member volunteered space: [Professor Laurel Wilkening's](#) driveway in Winterhaven probably still shows blotches of blue and red textile ink. Along the way, we printed the first Lunar & Planetary Lab T-shirt. Guy Consolmango, not yet a Jesuit, came up with a suitable design and Latin inscription: *Ex Nebula Solari, Planetes*. We'd wanted this to mean, "Out of the solar nebula came planets." LPL's resident atmospheric chemist and latin scholar, [Godfrey Sill](#), pointed out three mistakes in Guy's Latin (can you find 'em?).





## Department

### Meet LPL Postdocs: Kamber Schwarz and Mihailo Marinović

Kamber Schwarz joined LPL in September 2018 as a NASA Hubble Fellowship Program Sagan Fellow working with Associate Professor Ilaria Pascucci. Kamber's research combines millimeter and sub-millimeter observations with chemical modeling to study the molecular content and physical properties of protoplanetary disks. She is interested in constraining the timescales and mechanisms for the removal of volatile molecules from the disk gas, with the goal of determining the amount of volatile carbon, nitrogen, and oxygen available to forming planets.



Kamber grew up in Hereford, Arizona. She received her B.S. in Astronomy and Physics in 2012 from the University of Arizona, where she was also a NASA Space Grant intern. She earned her Ph.D. in Astronomy and Astrophysics from the University of Michigan with Professor Edwin Bergin (2018). Her graduate work focused on characterizing the abundance of volatile molecular gas in disks. During her free time, Kamber practices yoga and plays table-top games.



Mihailo Martinović came to LPL in September 2018 as a Postdoctoral Research Associate working with Assistant Professor Kristopher Klein. His research focuses on understanding of the acceleration and heating mechanisms of the solar wind through measuring and describing fluctuations of electromagnetic field in the solar wind plasma. Answering these questions is the main task of two current major heliospheric missions—NASA's Parker Solar Probe and ESA's Solar Orbiter, on both of which Mihailo actively participates, as well as one of the central unresolved topics in current heliophysics.

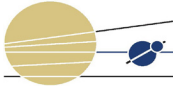
Mihailo was born and raised in Ivanjica which is in western Serbia. He obtained a B.S. in Applied and Computational Physics (2011), and a M.Sc. degree in Theoretical and Experimental Physics (2012) at the University of Belgrade, Serbia. He earned his Ph.D. in Space Plasma Physics at the University of Belgrade and Paris Observatory in 2016. His dissertation topic was a study of the quasi-thermal noise that appears due to fluctuations of the electric field in a plasma and is measurable in the interplanetary medium.

When he's not working, Mihailo enjoys reading historical and philosophical books, playing chess, and practicing karate—he has a Master (black belt) degree in Shotokan style karate—and spending time with his family.

### Spring 2018 GTA Award to Tracy Esman



Tracy Esman is the recipient of the PTYS Outstanding Graduate Teaching Assistant (GTA) Award for Spring 2018. Tracy was a GTA for PTYS/ASTR 170B2, with Dr. Steve Kortenkamp as instructor. Tracy carried a significant workload after a change of instructors early in the semester, helping to transition students to new assignments and assisting the instructor in bridging expectations. One of the student nominators wrote that, during the transition, "... things were crazy for a while! But Tracy was like a rock!" Tracy also prepared and presented a course lecture on the topic of the Moon, and was solely responsible for the term paper assignment, in addition to grading and review session responsibilities.



## Department

### LPL Fieldtrip Fall 2018

by Christopher Hamilton

This semester the LPL Graduate Students, led by **Christopher Hamilton** and **Joseph Spitale**, travelled to the Petrified Forest National Park and Canyon de Chelly National Monument. The focus of the field trip was to explore the geological record of northeastern Arizona to better understand processes and paleo-environments that existed during the time of Pangea; and to develop a deeper sense of place by understanding the cultural significance of geological landmarks within the Navajo Nation.

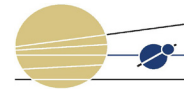
On the first day of the field trip, the group visited the Petrified Forest, which is known for its fossils and particularly for its well-preserved fossilized trees. In the National Park, archaeologist Amy Schott helped to provide students with the opportunity to both examine the exceptional fossilized trees from the Triassic Period and better understand the cultural significance of the region for Navajo, Hopi and Zuni people, as well as for Pueblo settlers and even older nomadic communities.



On the second day, the LPL group visited to Canyon de Chelly, where the park guide introduced students to the geological and cultural history of the region. The LPL group was fortunate to be able to walk into the canyon, descending past a major erosional unconformity at the base of the Late Triassic Shinarump Conglomerate (Lowermost Member of the Chinle Formation) and through cross-bedded layers of the Permian De Chelly Sandstone. In the canyon, students saw ancient dwellings of the Navajo people and petroglyphs etched into the walls of the Navajo and Ancestral Puebloans. On the third day of the field trip, the group revisited Petrified Forest National Park and first explored the northern part of the park, which provides sweeping view into the Painted Desert. The group then ventured along the Blue Mesa trail, which winds its way through colorful exposures within the Blue Mesa Member of the Chinle Formation. This geological member underlies younger sandstone unit that contain petrified logs, and as the overlying units are eroded, some of the fossilized wood is transported down into the gullies. Some of the larger petrified logs locally form erosion resistant caprocks that lead to the development of wild erosional landforms as the surrounding material is stripped away.

After three intense days, the LPL group returned to Tucson and is now looking forward to next semester's field trip to White Sands National Monument.





## Outreach

### Summer Science Saturday 2018

This year's Summer Science Saturday public open house event featured the Parker Solar Probe (PSP). Professor Joe Gialalone, co-investigator for the Integrated Science Investigation of the Sun instrument aboard PSP, presented a lecture titled, Parker Solar Probe: A Mission to Touch the Sun.

Over 300 attendees spent time learning about a variety of research and disciplines through displays and activities provided by numerous local groups, including LPL graduate students, OSIRIS-REx, UA Laboratory of Tree-Ring Research, Planetary Science Institute, Texas Instruments, Tucson Amateur Astronomy Association, Flandrau Science Center & Planetarium, Arizona Native Plant Society, UA Insect Collection, UA Mirror Lab, and the International Association of Astronomical Artists, among several others.

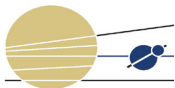
Next year's Summer Science Saturday, *Apollo 50: Next Giant Leap*, is planned for July 20, 2019, in celebration of the 50th anniversary of the Apollo 11 moon landing and in anticipation of future exploration of the moon and Mars.



### HiRISE in Latin



HiRISE is now part of the curriculum for a high school class in Avellino, Italy. This year, the students of the second class, section A, of the classical high school Publio Virgilio Marone, will translate Mars photo captions into Latin as part of a collaboration with HiRISE through the *BeautifulMars Project*. The captions will be translated under the guidance of professors Gabriele Alfinito (Latin), Nobile Paciello (English), and Aniello Mazzei (Sciences) and videos will be created to illustrate the work done. All this is possible with the full support of the school's principal Luigia Trivisone. Everyone is proud to collaborate on the project!



## Graduate

### Recent PTYS Graduates

Congratulations to the five students who completed their doctorates over the summer and fall 2018 semesters!



Corwin Atwood-Stone



Sky Beard



Ali Bramson



Ethan Schaefer



Xianyu Tan

**Corwin Atwood-Stone** is currently an instructor of Physics at Hinds Community College (Raymond, Miss.). He defended his dissertation, *Planetary Granular Topography: Slope Angles and Crater Concentric Ridges*, on July 26. **Alfred McEwen** was Corwin's research advisor.

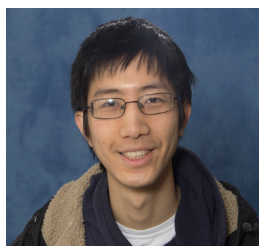
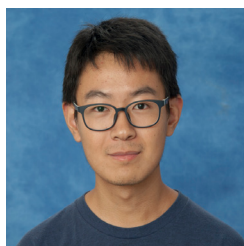
**Sky Beard** defended *Noble Gas Chronology of Meteorites: Brachinites, Ureilites, and Chelyabinsk* on September 24, and will begin a postdoctoral position at the University of Macau. Sky was advised by **Tim Swindle**.

**Ali Bramson** defended her Ph.D. dissertation titled, *Radar Analysis and Theoretical Modeling of the Presence and Preservation of Ice on Mars*, on July 31. **Shane Byrne** served as Ali's advisor. Ali is currently a Postdoctoral Research Associate at LPL.

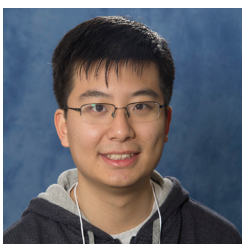
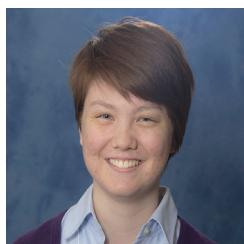
**Ethan Schaefer** defended his dissertation, *Quantifying Geomorphic Features: Relative Albedos, Skeletonization, and Multi-fractality*, on November 19, with **Alfred McEwen** as dissertation chair.

**Xianyu Tan's** defense of *Atmospheric Circulation of Brown Dwarfs and Directly Imaged Extrasolar Giant Planets* took place on November 2. He has accepted a position as a postdoctoral scholar at Oxford University. **Adam Showman** served as dissertation chair.

### 2018/2019 Admitted Graduate Students



From left to right:  
 Xiaohang Chen (Beijing University)  
 Weigang Liang (Cornell University)  
 Kiana McFadden (Jackson State University)  
 Tyler Meng (Colorado School of Mines)



From left to right:  
 Maureen Palmer (St. Olaf College)  
 Emileigh Shoemaker (Fisher College)  
 Harry Tang (Cornell University)  
 Brandon Tober (Texas State University)





## Department

# Unknown Treasure Trove of Planets Found Hiding in Dust

by Daniel Stolte, University Communications | December 6, 2018

New research by a team including LPL graduate student [Nathan Hendl](#) and LPL Associate Professor [Ilaria Pascucci](#) suggests that “Super-Earths” and Neptune-sized planets could be forming around young stars in much greater numbers than previously thought. Observing a sampling of young stars in a star-forming region in the constellation Taurus, researchers found many of them to be surrounded by structures that can best be explained as traces created by invisible, young planets in the making. The research helps scientists better understand how our own solar system came to be.



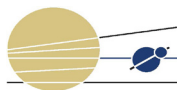
Some 4.6 billion years ago, our solar system was a swirl of gas and dust surrounding our newborn sun. This so-called protoplanetary disk had no discernable features, but parts of it began to coalesce into clumps of matter—the future planets. As they picked up new material along their trip around the sun, they grew and started to plow patterns of gaps and rings into the disk from which they formed. Over time, the disk gave way to the relatively orderly arrangement we know today. Scientists base this scenario on observations of protoplanetary disks around other stars that are young enough to currently be in the process of birthing planets. Using the Atacama Large Millimeter Array (ALMA), the team performed a survey of young stars in the Taurus star-forming region, a cloud of gas and dust located 450 light-years from Earth. When the researchers imaged 32 stars surrounded by protoplanetary disks, they found that 12 of them (40%) have rings and gaps, structures that according to the team’s measurements and calculations can be best explained by the presence of nascent planets.

While some protoplanetary disks appear as uniform, pancake-like objects lacking features or patterns, concentric bright rings separated by gaps have been observed. Previous surveys have focused on the brightest of these objects because they are easier to find, so it was unclear how common disks with ring and gap structures really are. This study presents the results of the first unbiased survey in that the target disks were selected independently of their brightness—in other words, the researchers did not know whether any of their targets had ring structures when they selected them for the survey.

The research team measured the properties of rings and gaps observed with ALMA and analyzed the data to evaluate possible mechanisms that could cause those rings and gaps. While these structures may be carved by planets, previous research has suggested that they may also be created by other effects. The researchers performed analyses to test these alternative explanations and could not establish any correlations between stellar properties and the patterns of gaps and rings they observed.

Because detecting the individual planets directly is impossible due to the overwhelming brightness of the host star, the team performed calculations to get an idea of the kinds of planets that might be forming in the Taurus region. According to the findings, Neptune-sized gas planets or so-called super-Earths should be the most common. Only two of the observed disks could potentially harbor behemoths rivaling Jupiter, the largest planet in the solar system.

Going forward, the research group plans to move ALMA’s antennas farther apart, which should increase the array’s resolution to around five astronomical units (one AU equals the average distance between the Earth and the sun), and to make the antennas sensitive to other frequencies that are sensitive to other types of dust.

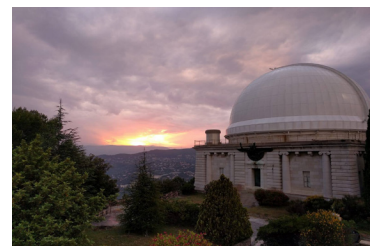


## Invest in LPL

### Summer Travel: 2018 Curson Travel Award

Two PTYS graduate students and a PTYS undergraduate minor were awarded 2018 Curson travel awards.

**Saverio Cambioni.** The Curson Travel Award supported my expenses for airfare to visit the Observatoire de la Côte d'Azur (OCA) (June to July 2018), and I collaborated with Dr. Marco Delbo on thermal modelling of asteroids. Working in Marco's group allowed me to learn that infrared measurements are crucial for the characterization of airless bodies. While at OCA, I learned how to master the TPM code (Delbo et al. 2015), which turned out to be a very important tool for my present and future research.



At OCA, my project consisted in creating a neural network representation of Dr. Delbo's TPM code, trained on a (4-D) grid of simulations performed using the TPM code. The developed surrogate model predicts the infrared flux associated with an asteroid whose surface is modeled by means of 4 parameters: thermal inertia of the regolith, thermal inertia of the rock, rock abundance and surface roughness. Once validated, the surrogate model can be statistically inverted using Markov Chain Monte Carlo inversion methods. This new methodology has been proved to be able to constrain the properties of the surface of bodies such as asteroid (101955) Bennu—target of the OSIRIS-REx mission, for which we inverted simulated fluxes—and (25143) Itokawa, for which we successfully inverted observed ground-based infrared data (Cambioni et al. 2018, in preparation). The research is particularly timely as both NASA OSIRIS-REx mission and JAXA Hayabusa II mission will begin their operations around the respective targets, in addition I also contacted other researchers involved in planetary formation studies, such as Dr. Alessandro Morbidelli and Dr. Paolo Tanga, and I had the opportunity to give a seminar about my research regarding machine learning application to characterize similar-sized collisional event (Cambioni et al. 2018, EPSC).

**Indujaa Ganesh.** The Curson award helped me travel to Serbia to participate in the Workshop in Geology and Geophysics of the Solar system. This workshop was held from June 23-July 1 in the Petnica Science Center in the village of Petnica, in Serbia, and was attended by planetary science graduate students and research scientists from different parts of the world. This is the first workshop of its kind that brought together new and experienced scientists in the field of planetary geology from many international institutions. The workshop was structured around a series of lectures by participating faculty and scientists. The talks covered several topics related to geology, geophysics and geochemistry of solar system objects. The speakers also talked about their ongoing research work, some of it unpublished, which was very exciting to hear about. As a graduate student in the early stage of my program, this was very helpful in understanding the various research problems that are currently being addressed in our field. In addition, it was also a great opportunity for networking with a small group of international researchers.

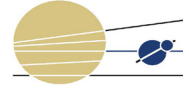


I have been studying the near subsurface structure of the caldera of Arsia Mons volcano on Mars using SHallow RADar (SHARAD). The radar sees layered structure in the subsurface which is unusual in volcanic terrains. I got the chance to present a poster and discuss my results with other researchers during these poster sessions.

**Adriana Mitchell.** The Curson Travel Award supported my travels to Tokyo, Japan to work at the Japan Aerospace Exploration Agency (JAXA) for six weeks. During the summer of 2018, I was given the rare opportunity to work at JAXA on their asteroid sample-return mission, Hayabusa2. I arrived at the mission headquarters just as the spacecraft was approaching the target asteroid, Ryugu. Working with Dr. Lucille Le Corre, a Hayabusa2 participating scientist from the Planetary Science Institute, I created 3D topographic models of the asteroid's surface in real time using observations from the instruments onboard the spacecraft. These models were used by JAXA to select a sampling site on Ryugu and to investigate the geology of various surface features.



I also prepared and selected different terrain models for efficient use during the approach phase and preliminary mapping phase of the mission. I was able to successfully collaborate with international scientists from Japan, France, Germany and Italy as we worked towards a common goal. Moreover, one of my goals during my time at JAXA was also to understand the organization and communication of a science team during a mission-critical event, as this experience will be beneficial to my future career at NASA.



## Invest in LPL

### 2018 Carson Fellowship to Maureen Palmer

Maureen Palmer is the recipient of the 2018 Carson Fellowship Award, which provides one academic year of support, including salary, tuition, and a supply stipend. Maureen is a first-year graduate student at LPL.

Maureen grew up in Shoreview, Minnesota. Her interest in a scientific research career was ignited by her experience competing on Mounds View High School's Science Olympiad team. Maureen attended St. Olaf College from 2012 to 2016 and graduated with a Bachelor's degree in Chemistry. She had the opportunity to participate in a variety of research experiences, including ecology projects (in St. Olaf's Natural Lands and in Tamil Nadu, India) and organic chemistry lab research. She competed on St. Olaf's Parliamentary Debate team and, in addition to science, took a significant amount of coursework in philosophy.



Maureen first became interested in space sciences after reading *The Eerie Silence* (a book about astrobiology, which she recommends to everyone). This book explores astrobiology concepts such as estimating the chances of life on other planets and the possibility of a "shadow biosphere," chemically distinct from our type of life, on Earth. After reading this book, Maureen was inspired to pursue academic research in astrobiology. She spent two summers working as an Undergraduate Research Associate in Astrobiology at NASA Goddard Space Flight Center. There, she worked with Dr. Martin Cordiner using Atacama Large Millimeter/sub-mm Array (ALMA) calibration data to detect and study new molecules in Titan's atmosphere. After graduating from college, Maureen returned to Goddard for two years, continuing to use ALMA data to study Titan's atmosphere and cometary comae. In her spare time, she also volunteered as an astronomy educator at the Smithsonian National Air and Space Museum's public observatory.

Maureen's detection in Titan's atmosphere of vinyl cyanide (C<sub>2</sub>H<sub>3</sub>CN), which had been suggested as a possible component of cell-like membranes in Titan's lakes, was published in July 2017 in *Science Advances*. She also worked on developing a new technique to analyze existing ALMA datasets, treating the ALMA array as a collection of single-dish telescopes, which improves its sensitivity to large-angular-scale objects like comets. In addition, she has been developing methods for systematically utilizing the wealth of data available in the ALMA Science Archive.

Maureen looks forward to continuing observational study of astrobiologically-interesting icy moons.

### Thanks to LPL Donors

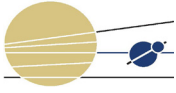
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## LPL in the News

Links to the news stories below and others are available at: <http://www.lpl.arizona.edu/news/2018/fall>

**LPL Lab Played a Big Role in InSight Mars Landing** - HiRISE pictures from orbit helped InSight mission planners choose a safe place to land.

**Excellence in Planetary and Space Sciences Highlighted in UA Strategic Plan** - UA President Robert Robbins outlines 10-year road map for UA's future which includes goals to become the No. 1-ranked school in space and planetary science and technology.

**BENNUVAL! Celebrates the Spirit of Human Curiosity** - As OSIRIS-REx approaches the asteroid Bennu, a family-friendly variety show explores how space unites science and the humanities.

**LPL Team Aiming for Jupiter Moon, with a Stop in Greenland First** - Greenland was the location of an analog mission to test a seismometer which hopefully will be selected for an upcoming Europa lander mission.

**Rare Blue Asteroid Reveals Itself During Fly-By** - A team led by LPL doctoral student Teddy Kareta obtained a rare glimpse of the bizarre, blue asteroid that is responsible for the Geminid Meteor Shower.

**Ceres Takes Life an Ice Volcano at a Time** - In a new study by LPL scientists, observations prove that ice volcanos on the dwarf planet Ceres generate enough material to fill one movie theater each year.

**One Small Step, No Small Feat: LPL's Long History with NASA** - Since 1964, LPL has been part of virtually every NASA planetary mission. However, the relationship between the two predates even the moon landing.

**Two LPL Scientists Part of Historic Mission to 'Touch the Sun'** - The NASA Parker Solar Probe's voyage to the sun is going to bring us closer to our star than ever before, and two LPL faculty members are helping with the first-of-its-kind space project.

**LPL Mars Camera Watching Dust Storm From Orbit** - The HiRISE camera flying above Mars is zeroing in on a raging dust storm on the red planet, giving scientists a chance to focus on the storm's impact on different parts of the Martian surface.

**Christopher Hamilton Explores the Architecture of Other Worlds** - LPL's Assistant Professor Christopher Hamilton wanted to be an architect, but today he is exploring a very different kind of built environment: the strange structures created by volcanos on worlds across the solar system.

**UA Undergrad Works to ID OSIRIS-REx Touchdown Site** - Systems engineering and mathematics double major Keara Burke is helping NASA's OSIRIS-REx spacecraft find the perfect place to collect samples when it reaches its far-flung destination, the asteroid Bennu.

**Comets Catch the Eye of LPL Planetary Scientists** - The paths of Jupiter-family comets are twisted into tighter orbits around the sun by the gravity of that planet.